# Exploring the Potential of Miniaturized Electrodynamic Tethers to Enhance Femtosatellites and Picosatellites Capabilities

Iverson C. Bell, III , Nikhil Shastri, Brian E. Gilchrist
The University of Michigan, Ann Arbor, Michigan 48109, USA
(734) 763-6230
icbell@umich.edu

Sven G. Bilén and Jesse K. McTernan
The Pennsylvania State University, University Park, Pennsylvania 16802, USA
814-863-1526
sbilen@psu.edu

The evolution of the millimeter-scale wireless sensor network concept and the promise and success of nanospacecraft (1–10 kg) have generated interest in even smaller, sub-kilogram scale, "smartphone"-sized spacecraft, either as stand-alone satellites or as elements in a maneuverable fleet. The satellites are categorized as picosatellites (100 g–1 kg) and femtosatellites (<100 g) and, due to their small size, they can be much less expensive to launch into orbit. In particular, it may be possible to deploy them in large numbers to enable missions requiring a distributed fleet of sensor spacecrafts (e.g., distributed aperture or simultaneous spatial sampling).

However, without some degree of propulsion, these spacecraft would behave more as an uncontrolled *swarm* rather than a coordinated, controlled formation. Further, lifetime is limited for low-mass spacecraft with high area-to-mass ratios. While a satellite using a chemical or electric propulsion system with proper attitude pointing can overcome the continuous force of atmospheric drag, the volume of propellant required will increase with the satellite's intended lifetime. Thus, the use of a traditional thruster with propellant and directed flow to compensate for drag and possibly for maneuverability would significantly increase the size, mass, and complexity of pico- and femtosatellites.

In this paper, we present progress on trade studies that investigated the use of a very short (few meters), semi-rigid electrodynamic tether (EDT) for pico- and femtosatellite propulsion. We analyzed the EDT anode's ability to draw current from the ionosphere and generate thrust and have traded this performance against the power needed to determine the EDT's capability of overcoming atmospheric drag forces. The study led to the development of a system concept and mission scenario. The results reveal that an insulated tether, only a few meters long, can provide these satellites with complete drag cancellation and even the ability to change orbit. Further, a few-meter tether could also serve as a communication or scientific radio antenna and enable plasma probe diagnostics. Additionally, the paper describes the Miniature Tether Electrodynamics Experiment (MiTEE) CubeSat mission being developed to test the fundamental concept of short EDTs for miniature spacecraft. Interestingly, the capability of propellantless maneuvering represents an opportunity for any constellation of femtosats to be less of an uncontrolled swarm and more of a long-term controlled fleet.